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Progress of Impurity Influx Monitor (divertor) for ITER
ITERダイバータ不純物モニターの開発の進展

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The impurity influx monitor (divertor) is one of the diagnostic system developed by Japan. In order to increase the detected signals, new optical design work has been carried out by using achromatic lenses. As a result, the detected signal was expected 10 times larger. The impact of the in-vessel wall refection to the optical diagnostic in ITER is an important issue. We measured the By-directional Reflection Distribution Function (BRDF) on the Tungsten block used in the divertor dome and baffle, and simulated by using the ray-tracing code and a model of the Tungsten block surface. Simulated result was qualitatively agreed with the measured one.

1. Introduction

Main objective of the Impurity Influx Monitor (divertor) for ITER is to measure the position of the ionization front, the density profiles, and influxes of impurities and hydrogen isotopes (H, D and T) in the divetor region in order to control the divertor plasma. In order to realize measurements, four optical systems are installed on the four positions, that is, on the upper port, the equatorial port, the divertor port and the divertor cassette.

In this paper, we present the new optical design using the achromatic lenses to increase the detected signal and to restrict the increase sizes of the components. The result of By-directional Reflection Distribution Function (BRDF) measurement of the tungsten block used on the ITER divertor baffle and dome, which are the fundamental data for the estimation of the effect of the wall reflection is also presented.

2. New Optical Design

In order to measure weak spectra, it is necessary to increase detected signals. All the optics are installed a narrow space in the port plug, the divertor port, the divertor cassette, and the port cell. Sizes of optical components are restricted.

The detected signals have been estimated by using the B2-EIRENE code and Collisional radiative model [1]. The result indicated that it was necessary for the measurement of the weak line such as HeI generated by the fusion reaction to increase the detected signals up 10 times larger than the present design. If we design the optical system by using mirror only, the size of the collection optics became very large and there was no space to install the optical fiber array to transfer the receiving light to the spectrometers.

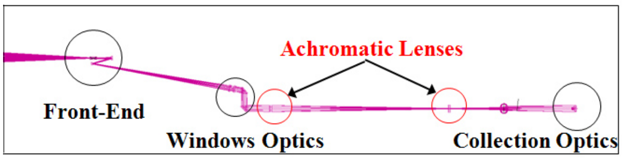

Fig. 1 Top view of the new equatorial port optics. Two achromatic lenses are installed outside the vacuum vessel.

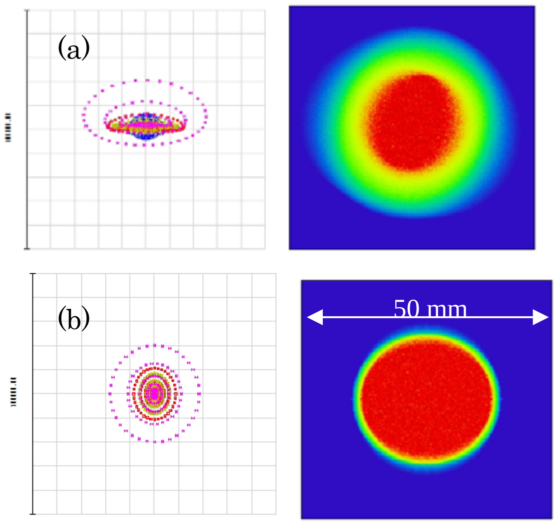

Fig.2 Spot diagrams and images of optical fiber (0.2 mm dia.) at divertor region. (a) light starts from the edge of the fiber array (b) light starts from the center of the fiber array

Then, the achromatic lenses have been used for reduction of the size of the collection optics and installation of the optical fiber array as shown in Fig.1. The achromatic lenses are made of silica

(SiO_2) and high purity calcium fluoride (CaF_2). The degradation of transmittance of CaF_2 was small after γ-ray irradiation up to 30 kGy but the effect of the neutron irradiation has been not known now. As a result of optical design code analysis, the numerical apparatus (NA) for the optical fiber side was increased up to 0.12 from 0.03. As a result, the detected signal increases ore than 10 times larger and weak line such as HeI generated by the fusion reaction is expected to be measured.

The spot diagram and the image of optical fiber (0.2 mm dia.) on the divertor are also calculated by using the optical design code. The size of the optical fiber array is 2 mmW x 18 mmH. The light started from center of the optical fiber bundle and the corner of the optical fiber is shown in Fig. 2 These results indicate that the image of the optical fiber (0.2 mm dia.) on the divertor region is less than the required value of 50 mm.

3. Effect of the Wall Reflection

In the ITER optical measurement system, the effect of the wall reflection on the measurement is an important issue. Because the first wall of the vacuum vessel is covered by Beryllium and the divertor dome and baffles are made of Tungsten. The surface reflection from the W surface seems to have a large influence on the impurity influx Monitor. In order to assess the effect, the measurement of BRDF of materials is necessary. We measured BRDF of the tungsten (W) surface. The W-surface milled by the fraise was measured by using the laser microscope. The measured engraved lines were linear shape and the maximum depth was 2.8 μm. The space between the engraved lines was 1 to 100 μm.

In the case the light incidented perpendicular to the engraved lines, reflected light traced linear in the incidence plane. On the other hand in the case the light incidented parallel to the engraved lines, the reflected line traced an arc shape as shown in Fig. 3.

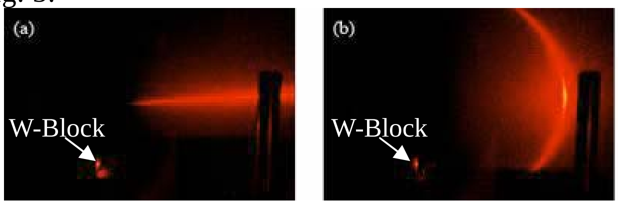

Fig.3 Image of the reflected light (a) light incident perpendicular to engraved lines (b) light incident parallel to the engraved lines

We measured BRFD of both case by using the 2 laser diode (λ = 652 nm and 473 nm). In the case of the light incidents perpendicular to engraved lines, peak at the reflected light was that the reflected angle equal to the incident angle case. The significant difference was not observed between two wavelengths. In the case of the light incidents parallel to engraved lines, the reflected light was an arc shape. The radii of the arc and profiles of reflected light were decreased with increasing the incident angle

By using the measured W-surface model, we have been carried out for both the light incidents parallel and perpendicular to the surface. Figure 4 shows models and obtained images. The obtained image was qualitatively agrees with that of measured one.

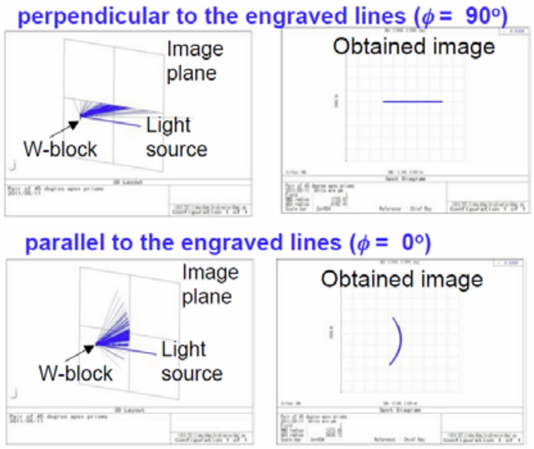

Fig. 4 Ray-trace analysis of the reflection of the W-surface.

4. Smmary

In order to increase detected signals, new optical design have been carried out by using achromatic lenses made of silica and the calcium fluoride as a results detected signal expected 10 times larger and the size of collection optics is almost same as previous design. And the BRDF of W-surface was measured. To evaluate the effect of the surface reflection on the optical measurement in ITER, simulation using the LightTools code will be carried out in the future.

References

[1] A. Iwamae, T. Sugie, H. Ogawa and Y. Kusaama: Plasma and Fusion Res. Vol. 4 49 (2009).